Empowering Farmers to Enhance Water Use Efficiency: Innovative Practices in SSPC

ABSTRACT

The Sardar Sarovar project, featuring a gravity dam on the Narmada River in Gujarat, stands as one of the largest in terms of concrete volume globally. This study investigates the project's extensive canal network and its impact on agricultural productivity in the command area. Covering a vast expanse across multiple states, the project's irrigation allocation and water management strategies are examined. Special attention is given to addressing soil degradation issues, particularly salinity, and implementing farmer-centered interventions to enhance water use efficiency. Methodologies include land rejuvenation efforts, reclamation of salt-affected land, participatory irrigation management, and promoting improved agricultural practices. Results indicate successful mitigation of soil degradation and increased crop yields through strategic interventions like cotton-castor relay cropping which has demonstrated a 1.5-fold increase in income compared to sole cropping. Intercropping with isabgul/ajwain, and implementing deficit irrigation have resulted in a substantial 43% increase in overall yield, particularly in cumin cultivation. Farmers have also embraced innovative water-saving techniques, such as alternative furrow irrigation and strategic timing of irrigation during critical growth stages, resulting in water savings of 30-35%. However, challenges remain in achieving widespread adoption of participatory irrigation management practices. The study concludes with insights into the necessity of sustained social engineering efforts and community engagement for long-term water resource management and agricultural sustainability in the project area.

Keywords: Deficit Irrigation, Participatory Irrigation Management, Social Engineering Efforts, Soil Degradation,Water Use Efficiency.

1. INTRODUCTION

The Sardar Sarovar project stands as a monumental feat, featuring a gravity dam nestled along the Narmada River near Navagam, Gujarat. Renowned for its sheer scale, it ranks as the world's second-largest gravity dam in terms of concrete volume. With a Full Reservoir Level (F.R.L.) of 455 ft. and a canal extending from the right bank, reaching a full supply level of 300 ft. at its off-take point, its impact on the region's water landscape is immense.

The sprawling canal system spans 458.318 km through Gujarat before extending 74 km into Rajasthan, punctuated by 598 diverse structures. Comprising 44 branches, 727 distributaries, and 4459 minors, this network ensures water distribution across the vast expanse. Encompassing a command area of 18.45 lakh hectares, spanning from latitudes 21°40'N to 24°40'N and longitudes 69°33'E to 73°50'E, the terrain is predominantly flat, interspersed with undulating landscapes and hillocks. With fertile alluvial soils derived from the Deccan Traps, the region supports 3177 villages across 77 talukas in 17 districts of Gujarat.

Efficient water management is paramount, overseen by the 'Narmada Planning Group,' which meticulously divides the command area into 13 Agro-Climatic Regions (ACRs). Factors such as topography, rainfall, groundwater availability, and land irrigability inform water allocation tailored to each region's needs. However, the benefits of irrigation are not without challenges. Soil health and environmental degradation, exacerbated by salinity, pose significant hurdles to sustained agricultural productivity. Approximately two-thirds of the command area grapples with semi-arid climatic conditions, exacerbating salinity issues. Coastal areas, known as 'Bhal' and 'Bara Track,' contend with coastal salinity and drainage problems, while the low-lying flats near the Little Rann of Kutch are afflicted by salt-affected soil.

In addressing these challenges, a concerted effort prioritizes farmers' concerns, recognizing their pivotal role in sustaining irrigated agriculture. Through targeted interventions, the project endeavors to mitigate soil and water quality deterioration, fostering a resilient agricultural landscape for generations to come.

2. METHODOLOGY

Appropriate strategic actions viz. mitigation measures for land affected by excessive seepage, reclamation of salt-affected land, conjunctive use of water, restricted use of pesticides has been successfully carried-out in Sardar Sarovar Project Command are discussed hereunder:

2.1 Rejuvenation of land affected by excessive seepage

In accordance with the Balgabaev[1], water losses due to seepage in the irrigation network is 30–35% in main canals, their branches and inter-farm distributors; 50–55% in on-farm irrigation networks. Consequently, only 24% of the water withdrawn is effectively used for crop irrigation.The excessive seepage in the fill segment of canal i.e. earthen embrace is a commonly occurring problem in commands. Such a problemof soil degradation was faced by the farmers of three villages having their fields adjoining Saurashtra Branch Canal. Located just on upstream of each of the three fall structures of canal based power houses. As the canal reaches in banking having full supply level quite above the ground level, the excessive seepage on both the sides had caused water logging condition. Normal cropping was under hindrance due to soil degradation. The farmers were demanding to take suitable measures to mitigate the problem, such as they can continue taking crops.

Initially, the problem was analysed using available historical and current soil and crop data. Potential mitigation strategies included measures to prevent seepage, such as installing intercepting drains, and implementing on-farm soil improvement techniques. These techniques encompassed suggestions like cultivating salt-tolerant crops, employing green manure, practicing crop rotation with legumes, minimizing the use of inferior groundwater, adopting lighter and more frequent irrigation, optimizing fertilizer selection and application methods, timing tillage appropriately based on soil moisture content, promoting the use of farmyard manure and compost, and implementing other scientifically evolved location-specific measures.

Following extensive consultation with stakeholders, an actionable plan was developed and finalized. This plan was then executed, leading to significant improvements. Consequently, farmers are now able to resume crop cultivation as before.

2.2Reclamation of Salt affected (Saline) land

The tail end regions of the Bolera and Rajpura branch canals within the Sardar Sarovar Project lie near the Little Rann of Kutch. These areas are characterized by inherent soil salinity, flat terrain, and groundwater of subpar quality, ranging from depths of 2.1 to 10.9 meters. Within the soil profile, there exists a calcium-rich layer at depths ranging from 1.2 to 4.0 meters, acting as an impermeable barrier. This layer inhibits water from moving downward, leading to temporary waterlogging across the entire area.

The soil in this region exhibits high concentrations of sodium (Na), bicarbonate (HCO3), and chloride (Cl), resulting in stickiness and salinity. Additionally, soil tests reveal that the soil falls within the categories of 'highly' to 'very highly saline,' with a Sodium Adsorption Ratio (SAR) exceeding 20, indicating an alkali hazard. The presence of chloride hardens the soil, while bicarbonate makes it sticky and soft. The combination of these elements renders the soil prone to swelling, stickiness, and an oily appearance.The reclamation of salt-affected soils follows the exact reverse of the process by which they are formed. (Britannica, 2024)

2.3Participatory Irrigation Management

As outlined in the 'Water Use Plan' of the Sardar Sarovar Project (SSP), the initial delta available at the head of the main canal is approximately 550 mm, which may decrease to around 320 mm at the field level. Meeting irrigation demands with this reduced delta presents a significant challenge. Hence, maximizing the efficient use of canal water becomes imperative. The agricultural sector, in particular, has considerable scope for improvement in water conservation through educational, economic, and policy measures.

The situation in the Sardar Sarovar Project is particularly critical due to the anticipated reduction in allocated delta. While the development of physical infrastructure is integral to irrigation projects, the ultimate goal lies in achieving higher water use efficiency. In this context, success hinges not only on the creation of infrastructure but also on effective Participatory Irrigation Management and the adoption of improved crop and agricultural practices.Water users' associations (WUAs) are formed to organize local farmers and facilitate their engagement in planning and managing water distribution and use.(Chattopadhyay S. 2022)The government has accepted the concept of Participatory Irrigation Management which ensure equitable and efficient distribution of irrigation water.

2.4Farmer Centered Interventions

It was felt needed to create interest among the beneficiary farmers for practicing PIM such as to achieve higher Water Use Efficiency. Farmers are mainly interested in their income through agriculture. Specifically providing support in resolving agricultural problems, enhancing their income may win the confidence and faith towards better irrigation management. In view of this few such approaches made in the SSP command are discussed here under.

2.4.1 Restricted use of pesticide

The use of pesticides increases with the intensification of agriculture as along with the creation of irrigation facility. The pesticides are considered a vital component of modern farming, playing a major role in maintaining high agricultural productivity. However, cognizance and practices of the farmers for pesticide use, and risks associated with it was not satisfactory and exposes them to adverse health outcomes(Sachan B. 2022).The presence of pesticide residues poses a significant threat to groundwater contamination, which is particularly concerning as groundwater serves as a primary source of drinking water. While the use of pesticides in modern agriculture may seem unavoidable, employing them judiciously and adopting recommended methods can greatly mitigate this issue.

To proactively address this concern, pesticide residue monitoring at the Sardar Sarovar Project Command (SSPC) was initiated in 2009 in collaboration with the All India Network Program (AINP) on Pesticide Residue, ICAR, Unit-9, Anand. Strategic sampling locations were scientifically selected to collect surface runoff water from ponds and sub-surface water from open wells. A total of 176 pesticides were monitored through multi-residue analysis, with a detection limit of 0.5 µg/L (ppb).

2.4.2 Improved practices of cumin cultivation

India holds the title of being the largest producer and consumer of cumin seeds globally. Within India, Gujarat stands out as a key contributor to cumin production, accounting for over 60 percent of the country's total output. The cultivation of this high-value cash crop has seen a significant expansion following the availability of Narmada water for irrigation, thereby strengthening the Sardar Sarovar Project (SSP) command area.

Intercropping, the practice of growing two or more crops simultaneously on the same land, is a strategy that maximizes the use of limited arable land. Efficient intercropping not only enhances productivity but also helps maintain soil fertility (Singh et al., 2013). Additionally, it provides a safeguard against crop failure by ensuring income from multiple sources. Research suggests that intercropping cumin with ajwain in a 1:4 row arrangement, with ajwain harvested at 45 days after sowing (DAS), leads to higher cumin equivalent yields, gross returns, and net returns (Patel and Amin, 2017). There is an urgent need to emphasize more on constraints management related to soil and extension activities to create awareness among the farmers (Kumar et al., 2023).

2.4.3Cotton-Castor relay cropping

Cotton dominates the agricultural landscape, covering more than 40% of the command area. BT Cotton, in particular, is a high-demand crop with a rapid transition to the reproductive phase and a shorter growth period compared to hybrid cotton. Its spaced planting allows for efficient utilization of intra-row space. Relay cropping, a sophisticated amalgamation of resource-efficient technologies, holds promise in enhancing soil quality, increasing net returns, improving land equivalent ratios, and managing weed and pest infestations. Studies by Shirahatti et al. (2007) and Choudhary et al. (2016) have shown that furrow and drip irrigation methods result in higher Water Use Efficiency (WUE).

Castor, on the other hand, is a low-water-demand, long-duration cash crop. It can be intercropped between rows of BT cotton once the cotton crop enters the reproductive stage. This relay cropping system, implemented during the Rabi season, generates additional income. What sets the cotton-castor relay cropping system apart is the combination of two cash crops, enhancing farmers' economic prospects by cultivating cotton for textiles and castor for industrial purposes. Optimal plant spacing in castor cultivation significantly boosts yields.

2.5Development of Model ‘Village Service Area’

The Water Use Plan within the Sardar Sarovar Project command area introduces the concept of Village Service Area, encompassing a minor canal's coverage. While Participatory Irrigation Management is widely acknowledged as vital for the effective operation and maintenance of irrigation systems, instances of successful implementation remain scarce. To address this gap, a unique agricultural-centric approach was employed in developing a model Village Service Area (Vegadvav) in Halvad Taluka.

Farmers were encouraged, mentored, and facilitated in adopting improved agricultural practices aimed at enhancing their income. Scientific expertise was provided to farmers as needed, ensuring timely guidance and support. The implementation of Participatory Irrigation Management was an integral component of the overarching goal of achieving integrated agricultural development. This farmer-centric, bottom-up approach may take time to yield results but promises holistic and sustainable outcomes.

3. RESULTS AND DISCUSSION

3.1 Rejuvenation of land affected by excessive seepage

The farmers were provided with the possible mitigation measures of managing their land resources scientifically, as evolved from available knowhow/technologies, soil investigation report and interactive discussion/brainstorming among farmers, field staff and experts.However, water losses from irrigation canals are directly influenced by soil permeability, which is affected by several factors, including mineral composition, granulometric composition, porosity, stratification, temperature, and hydrostatic pressure (Aabd-Elaty et al., 2022)

3.2Reclamation of Salt-affected land

Through meticulous soil investigation, analysis, and interpretation, along with numerous consultations, field visits, and brainstorming sessions involving farmers, government officials, and experts, an integrated implementation approach has been devised. This approach comprises various activities aimed at adoption by farmers, along with the establishment of a robust surface drainage system. A cluster of 26 severely affected villages has been selected to pilot reclamation measures. The farming community is now actively engaged in the development process, particularly in reclaiming degraded land.

3.3Participatory Irrigation Management

To engage beneficiaries and stakeholders in irrigation management, the Government implemented the Participatory Irrigation Management (PIM) Act in 2007. Water Users' Associations (WUAs) were established from among the beneficiary farmers in the SSP command area, with the expectation that they would assume responsibility for operating and maintaining the system from the minor head and below, in addition to organizing community-based agricultural and economic activities. Despite concerted efforts to educate and involve WUA members, supported by competent NGOs and extension activities, farmer response has been sluggish, and the successful functioning of WUAs remains limited. Therefore, there is a pressing need for a distinct approach that can effectively engage the farming community in managing their crops with minimal water usage within the project.

3.4Farmer Centered Interventions

Each monitoring location for pesticide residue meticulously assessed the area contributing runoff water, with test results scrutinized to pinpoint the need for strategic preventive measures based on observations. Farmers in identified clusters, particularly vegetable growers around Padara and cotton growers around Karjan talukas, were personally educated and persuaded to adopt controlled pesticide use through integrated pest management, resulting in reduced costs. Consequently, the pesticide residue status across the entire Sardar Sarovar Project command area is currently reported as 'Below Detectable Level.'

A multitude of demonstrations on recommended improved practices, such as line sowing instead of broadcasting, raised bed sowing with drip irrigation, deficit irrigation practices, and inter-cultivation using wheel hoes, were undertaken. These practices led to an average productivity increase of 33%, along with water savings and an expansion of cultivated area from approximately 0.5 lakh ha to 1 lakh ha over the past three years. Furthermore, farmers were encouraged to adopt value addition techniques such as sorting and cleaning, resulting in higher economic returns.

The cotton-castor relay cropping technique, initially recommended by the State Agricultural University, underwent reassessment and appropriate modifications following a three-year trial at the Narmada Irrigation Research Project farm. Large-scale demonstrations were subsequently conducted on farmers' fields, revealing a 27% increase in income. This resource-efficient practice, offering higher returns to farmers, has been widely adopted in Karjan, Thasra, and Harij talukas, with the majority of farmers recognizing the benefits of this new cropping system.

3.5Development of Model ‘Village Service Area’

Community-driven initiatives, such as the construction of storage tanks, blending inferior groundwater with canal water, the adoption of Micro Irrigation Systems (MIS), Rotational Water Distribution, and diversification to high-value crops, alongside other improved agricultural practices and collective economic activities like input procurement and produce sales, have demonstrated significant success. Since its inception in 2010, over half of the land holdings now boast their own tube wells, appropriately sized storage tanks, piped water distribution networks, and MIS adoption. The remaining farmers are swiftly joining in this adoption process.

4. CONCLUSION

To fulfil the objectives of the Sardar Sarovar Project, a sustained, long-term effort is essential, encompassing the timely completion of identified activities and the implementation of established policies.The development activities within the command area primarily focus on improving Water Use Efficiency (WUE) in a sustainable manner, aligning with the project's water use policy. Central to this effort is the empowerment of Water Users Associations (WUAs) to manage water distribution through Rotational Water Supply and ensure its efficient utilization from the canal network, particularly at the minor and sub-minor levels. To achieve this, farmers undergo training in participatory irrigation management and specific crop management practices. However, successful outcomes have been limited.As a response, a bottom-up approach has been adopted, involving local farmers in the command area development process, particularly in crop and irrigation management. This approach aims to foster willingness among farmers and subsequently empower them with tailored support and facilitation as per their needs. While this farmer-centric approach may take time to yield results, it offers a holistic approach to enhancing water use efficiency sustainably by mobilizing the community.

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